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HOGLA LEAF AS A POTENTIAL BIO-ADSORBENT FOR THE TREATMENT OF REACTIVE DYES IN TEXTILE EFFLUENTS

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Abstract:

A new bio-adsorbent to remove reactive dyes from textile effluent was investigated in the present study. The adsorbent was the leaves of locally available hogla plant (Typha angustata). Initially, sunfix yellow, a reactive dye widely used in textile effluents, was used to check the removal efficiency in terms of contact time, pH of dye solution and adsorbent dosage. Complete removal (100%) of dye was achieved at adsorbent/dye ratio of 2300:1 at pH 10 with 180 minutes contact time. The adsorbent was then applied to deep colored, raw textile wastewater samples and it was found that 2.3 g of adsorbent was able to convert 100 mL of deep colored wastewater to transparent water at pH 10. Additionally, treatment by the adsorbent resulted in significant decreases in pH, BOD, COD, TS, TDS and TSS of wastewater, while improving the DO level.

Keywords: Bio-Adsorbent; Sunfix Yellow; Reactive Dye; Textile Wastewater; Hogla Leaf.

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1. Introduction

The global yearly production of 10,000 types of commercially available textile dyes has reached approximately 7.10×10^5 metric tons [1]. It is estimated that 2-20% of such dyes are directly released in various environmental constituents as aqueous effluents [2]. The World Bank estimates that 20% of global industrial water pollution comes from the treatment and dyeing of textiles [3]. On average, the textile processing industry requires 50-150 liters of water per kg (l/kg) of textile material processed [4] which is in sharp contrast with the fact that in many regions of the world less than 10 l of water is available per person per day.

At present, primary, secondary, and tertiary methods are used worldwide to treat wastewaters. Processes involved in primary treatment are mainly physical, and include screening, sedimentation, flotation and flocculation to remove fibrous debris, insoluble chemicals and particulate matter [4]. Secondary stages are designed to eliminate the organic load and consist of a combination of physico- chemical separation and biological oxidation [4].

Both primary and secondary treatment cannot significantly remove colored materials. Tertiary stages of treatment have become more important, but increase treatment costs. Also, some of these methods involve addition of more chemicals making the processes environmentally unfriendly [5]. Industry owners do not show interest to install these methods due to high running costs and maintenance problems [6]. Ultimately, in many developing countries particularly India, china, and Bangladesh, the untreated dye-enriched textile wastewaters are discharged directly into various water bodies contributing to environmental degradation, loss of aquatic lives, and harmful human health impacts [7].

In recent years, the uses of natural adsorbents have gained remarkable importance due to their low cost, environmental friendliness, local availability, and sustainability [8]. Khaleque and roy (2016) found that locally available banana fiber can remove novacron blue fn-r, yellow fn-2r, and red- fn 3gl reactive dyes from textile wastewater efficiently [9]. In this study hogla leaf is tested as an adsorbent to remove reactive dyes. It possesses granular structure, high chemical stability and high porosity which are very important characteristics for an efficient adsorbent [10]. The hogla leaf adsorbent is indigenous, renewable, cost-effective and environment friendly.

2. Materials and Methods

2.1. Materials

The raw hogla leaf was collected from Barisal district of Bangladesh. Sunfix yellow reactive textile dye was collected from Anwara Knit Composite Ltd., Mawna, Gazipur—a local textile and garments manufacturing company. Hydrochloric acid and hydrogen peroxide was purchased from BDH chemicals ltd, England. Sodium hydroxide was purchased from Merck KGaA, Germany. Acetic acid was obtained from Sigma-Aldrich. UV-Visible spectrophotometer (DR/4000U, HACH) was used to measure absorbance.

2.2. Methods

The raw hogla leaf was sun dried, ground in a blender (Philips, HR2118) and sieved with plastic sieve. The sieved leaf was washed with 500 ml of distilled water twice and filtered. It was then treated in 500 ml of 1.5% of sodium hydroxide and 1% of hydrogen peroxide with stirring at 60°C for 90 minutes and filtered again. Finally, the residual leaf was dried at 105°C for 24 hours. For drawing the calibration curve to determine the unknown concentrations of dye solutions, a stock solution of sunfix yellow dye was prepared by dissolving 0.1 g of dye in de-ionized water in a 1 l volumetric flask. The stock solution was then diluted to 5, 10, 15, 20, and 25 mg/l by adding de-ionized water. These standard solutions were scanned in the range 190-1000 nm with the uv-visible spectrophotometer to obtain the λ_{max} of the dye.

For the interaction of the adsorbent and dye solution, a specified amount of hogla leaf and sunfix dye solution was taken in a beaker and stirred using a magnetic stirrer for a specified time.

In a typical experiment 2.3 g of hogla leaf was interacted with 100 ml of dye solution of specified concentration. Afterwards that the adsorbent was separated from the aqueous phase by filtration. The absorbance of the filtrate was measured by the UV-Visible spectrophotometer at the λ_{max} to find out the dye concentration.

3. Results and Discussions

3.1. Calibration Curve for Sunfix Yellow Dye

The obtained λ_{max} was 510 nm. A calibration curve (figure 1) was drawn using the standard solutions of the dye and measuring their absorbance at 510 nm. The correlation coefficient (R^2) is found to be 0.9998 which proves the statistical validity of measurements. Therefore, the curve was used for determining unknown concentration for measured absorbances when required.

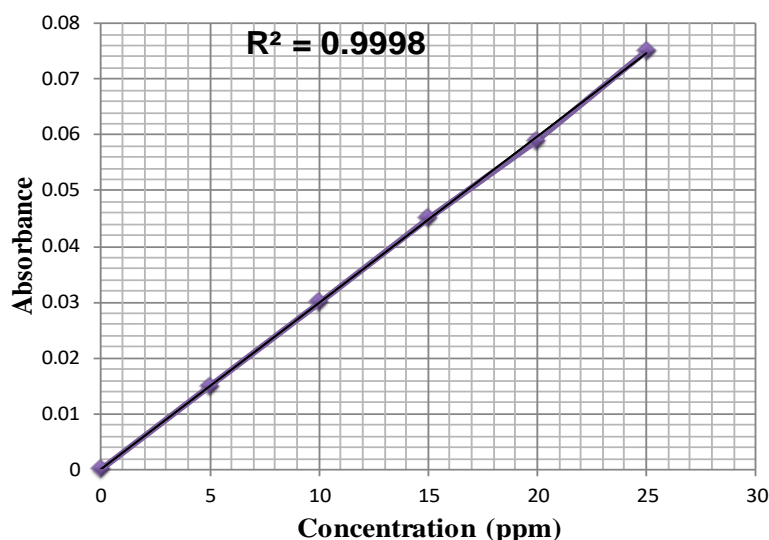


Figure 1: Calibration curve for sunfix yellow reactive dye

3.2. Interaction of Sunfix Yellow Dye with Adsorbents and Calculation of Removal Efficiency

The removal efficiency of dye was calculated by using the formula:

$$\text{Removal efficiency (\%)} = \frac{C_0 - C_e}{C_0} \times 100$$

Where,

C_0 = initial concentration of dye solution, mg/l

C_e = final concentration of dye solution, mg/l

3.3. Effect of Adsorbent Dosage on Adsorption

Effect of amount of adsorbent was studied to find out adsorbent/dye ratio that can result in quantitative adsorption with complete removal of dye from aqueous phase. The dosage of the adsorbent tested ranged from 0.5 to 4 g, added to dye solutions of fixed volume and concentration. Hogla leaf shows quantitative adsorption (100 % removal efficiency) at adsorbent/dye ratio of 2300:1 (figure 2).

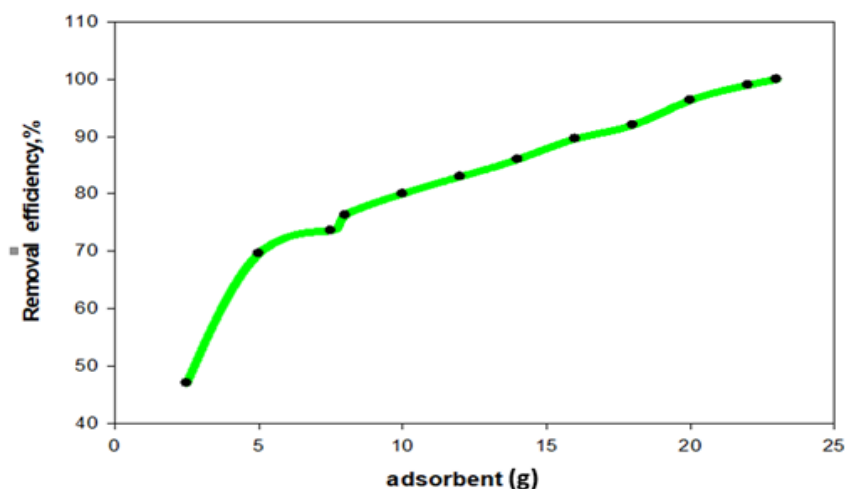


Figure 2: Effect of adsorbent dosage

3.4. Effect of pH on Adsorption

Adsorption of sunfix yellow on hogla leaf was observed in pH range 7-12. The maximum removal efficiency (80%) was resulted in pH 10, which is due to the fact that in acid medium bridging group present in dye is destabilized [11] leading to increase in removal efficiency with increase in pH (figure3). After pH 10, removal efficiency decreased significantly with only 74% at pH 12.

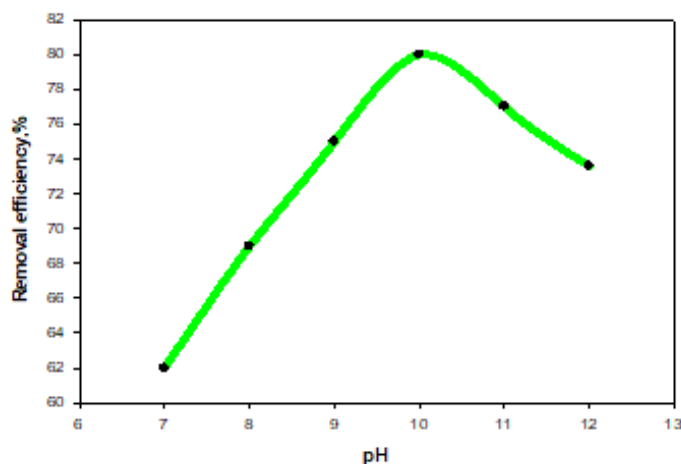


Figure 3: Effect of pH on adsorption

3.5. Effect of Initial Dye Concentration on Adsorption

Effect of initial sunfix yellow reactive dye concentration on adsorption on hogla leaf was observed as shown in figure 4. Contact time and adsorbent concentration used were 180 min and 10g/l. As initial dye concentration increased, adsorption capacity decreased because with increasing concentration, number of dye molecules increases in aqueous phase leading to lower removal efficiency

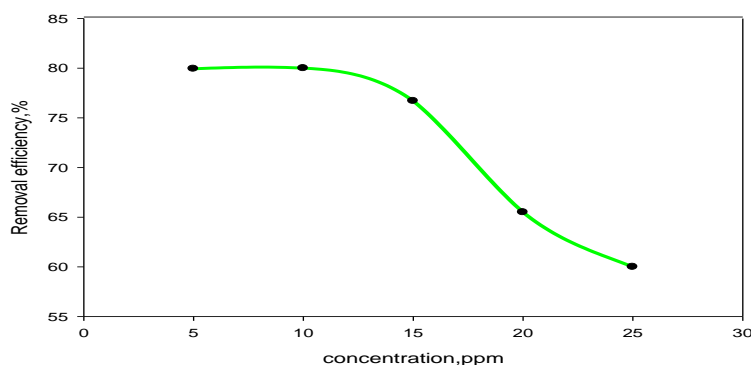


Figure 4: Effect of initial dye concentration

3.6. Effect of Contact Time on Adsorption

Effect of contact time for adsorption of sunfix yellow on hogla leaf was studied for a period ranging from 30-210 min while all other parameters remained constant. Observed removal efficiency is shown in figure 5. Removal efficiency gradually increases with time and reaches maximum (about 80%) in 180 mins. After that removal efficiency gradually decreases which could be due to possible desorption of dye molecules from surface of adsorbent.

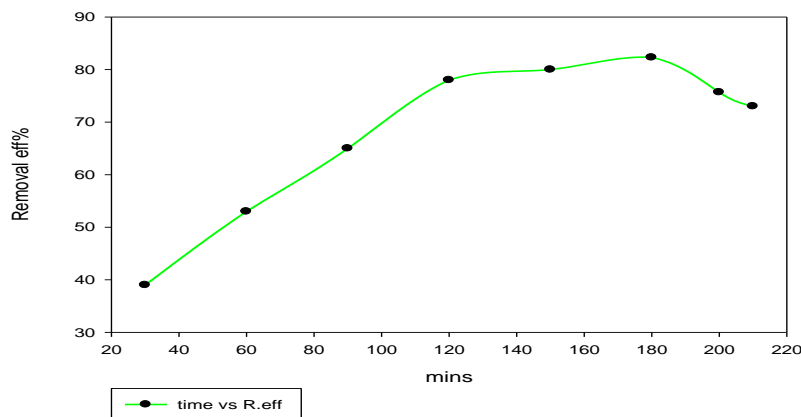


Figure 5: Effect of contact time

3.7. Interaction of the Adsorbent with the Raw Wastewater

Raw wastewater samples were collected from a leading textile manufacturer anwara knit composite, mawna, gazipur and preserved in refrigerator at 4°C. The following parameters were tested to characterize the preserved sample: pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total solids (TS), total dissolved solids (TDS), and total suspended solids (TSS). After the baseline values for these parameters were established, the wastewater is allowed to interact with the hogla leaf adsorbent.

After interaction with the hogla leaf adsorbent, pH of wastewater decreased from 12.6 to 10. This is because of the adjustment made to gain the optimum pH level for this adsorption system. DO level is found to increase approximately 16% after interaction. Significant decreases in bod (41%) and cod (31%) is observed after treatment as well. The TS, TDS and TSS decrease by 22%, 24%, 07% respectively due to adsorption. The values before and after the treatment are presented in table 1:

Table 1: Characteristics of raw textile wastewater before and after treatment

Parameter	Values	
	Before treatment	After treatment
pH	12.6	10
DO (mg/l)	6.08	7.07
BOD (mg/l)	43.2	25.2
COD (mg/l)	768	523
TS (mg/l)	3604	2815
TDS (mg/l)	3110	2356

Visual evaluation confirms that after treating with the adsorbent, the color of the wastewater was completely removed proving that the adsorbent is capable of removing reactive dyes from wastewater. (Figure 6)



Figure 6: Textile wastewater before and after treatment

4. Conclusions

In this research a new biomaterial hogla leaf was found to be very effective in removing reactive dyes from wastewater. Initially although a single reactive dye sunfix yellow was used, it is found that the adsorbent can remove other reactive dyes present in wastewater samples as well. Adsorption experiments carried out are affected by pH of dye solution, contact time and adsorbent/dye ratio. Highly alkaline pH favors adsorption process with peak removal efficiency (80%) at pH 10 over a reasonable contact time of 180 minutes. The adsorption dye ratio of 2300:1 is ideal for the present system to achieve 100% dye removal. Treatment by the adsorbent is found to decrease the pH, COD, BOD, TS, TDS and TSS while increasing do level of industrial effluent. Therefore, the study concludes that hogla leaf is a very efficient bio-adsorbent for removing several reactive dyes from the aqueous phase and can significantly improve physical parameters of textile wastewater before discharging.

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